Online Physiology 2130 - Endocrinology

Introduction

Dear Student,
Thank you for opening this resource for Physiology 2130, and welcome. This resource has been created by the Education Team at WebStraw. The Education Team consists of students that have previously taken and/or students that are currently taking Physiology 2130.

Purpose

This resource focuses on key concepts that are important for students to understand to succeed within this course. This resource was created by students for other students. Our goal is to help students (1) further develop their understanding of course content and (2) achieve greater academic success. (3) Our resource is also open access meaning there are no financial or legal barriers to students who wish to access and use our resource.

Instructions

These study resources consists of several parts. The first part includes a condensed review of the major takeaways from each physiology module. This is followed by a series of questions and fill in the blank worksheets that should be completed after you have gone through the module and course material, in order to verify your understanding.

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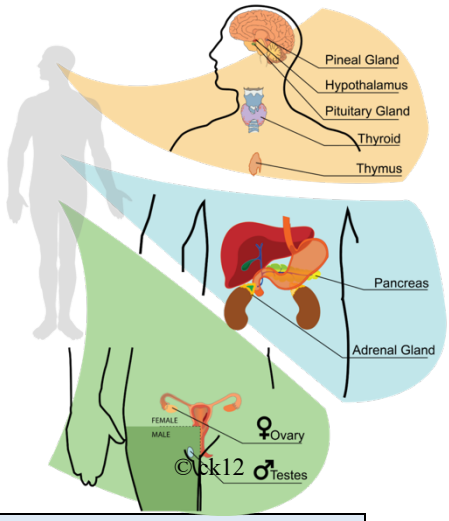
We wish you the best of luck on your exams!
The WebStraw Team

Note to Instructors: If this resource has been created for your course and you would like to collaborate with us, please email us at team@webstraw.ca

Module 13 – Endocrinology

Endocrine Glands and General Roles

- Group of specialized cells that synthesize, store, and release hormones into the bloodstream
- Hormones circulate throughout body to specific target cells that have receptors for the hormone, to inhibit or stimulate the cells' activity



Three Chemical Types of Hormones (based on Solubility)

1. **Thyroid** – derived from amino acid Tyrosine
2. **Protein** – calcitonin, parathyroid hormone and most of releasing/inhibiting hormones from hypothalamus
3. **Steroid** – derived from cholesterol: cortisol, aldosterone, estrogen, progesterone, and testosterone.

Protein Hormones	**Steroid and Thyroid Hormones**
Hydrophilic – circulate freely in the blood and cannot diffuse through the cell membrane	**Hydrophobic** – require protein carrier to circulate in the blood and can diffuse easily through cell membrane
Receptor – must be located on cell membrane of target cell since hormone can't diffuse into cell	**Receptor** – located inside the target cell

Secretion, Effects and Inactivation of Hormones

- Secreted into blood in "pulses" via distinct stimulus (blood-borne or neural)
- Amount varies w/strength of stimulus
- Act by regulating pre-existing reactions
- Secretion controlled by *negative feedback*

Hormone Receptors

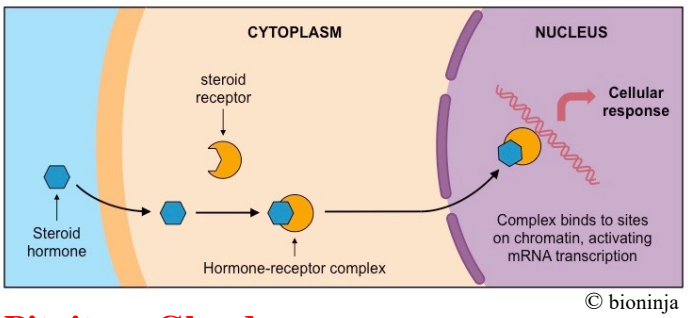
Hydrophobic – located in cytoplasm or in the nucleus

- Hormone binds to receptor, and hormone/receptor complex binds to DNA within nucleus

Hydrophilic – located on cell membrane

- Once attached, a sequence of chemical reactions is initiated that will eventually alter activity of cell

Can affect cell in three ways: second messenger system, via tyrosine kinase, or through G-proteins



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Pituitary Gland

Function:

- Called the "*master gland*" because its hormones help to regulate the functions of other endocrine glands
- Receives signals from hypothalamus to release or inhibit hormone production

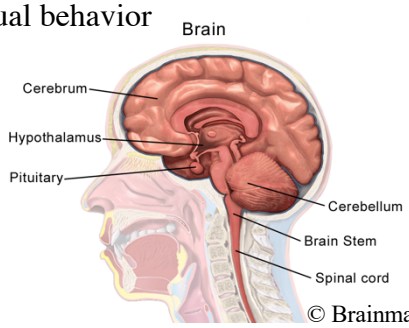
Hormone Metabolism/Removal

- After affecting the targeted tissue, hormones are broken down by different systems in the body
- Removal via: metabolic destruction in the blood or by other tissues (liver and kidney), excretion by liver into bile, or excretion by kidneys to urine

Hypothalamus

Function:

- Regulating homeostatic mechanisms: body temp., water balance, and energy production
- Regulation behavioral drives: thirst, hunger, sexual behavior



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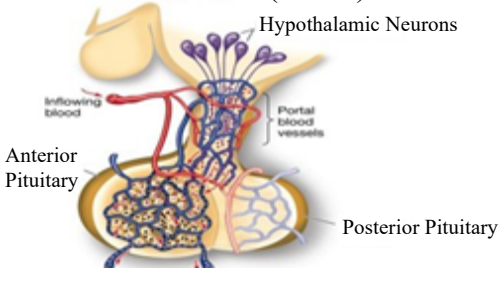
Location and General Structure:

- Base of the brain just above the pituitary gland and below the thalamus
- Composed of many regions that are made up of groups of nerve cell bodies (nuclei)



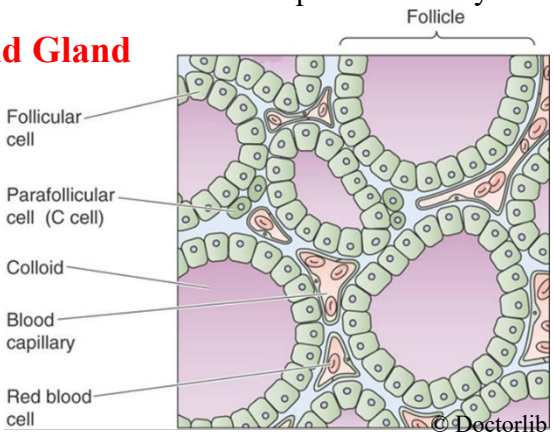
Anterior Pituitary Hormones

Hormone Secreted by Hypothalamus	Anterior Pituitary Hormone	Target Tissues
Gonadotropic Releasing Hormone (GnRH)	Luteinizing Hormone (LH) & Follicle Stimulating Hormone (FSH)	Gonads (Testes, Ovaries)
Thyroid Releasing Hormone (TRH)	Thyroid Stimulating Hormone (TSH)	Thyroid Gland
Corticotropic Releasing Hormone (CRH)	Adrenocorticotropic Hormone (ACTH)	Adrenal Glands
Growth Hormone Releasing/Inhibiting Hormone (GHRH/GHIH)	Growth Hormone (GH)	Various (bone, skeletal, muscle, liver, adipose)
Prolactin Releasing Hormone (PRH) & Prolactin Inhibiting Hormone (PIH)	Prolactin	Mammary Glands

Posterior Pituitary Hormones

- **Oxytocin**
  - Promotes uterine contractions
  - Promotes milk excretions
- **Antidiuretic Hormone (ADH)**
  - Causes water reabsorption in kidneys

Thyroid Gland



- Thyroid gland found below larynx (voice box)
- Composed of follicles – functional unit of thyroid
  - Colloid surrounded by epithelial (follicular) cells

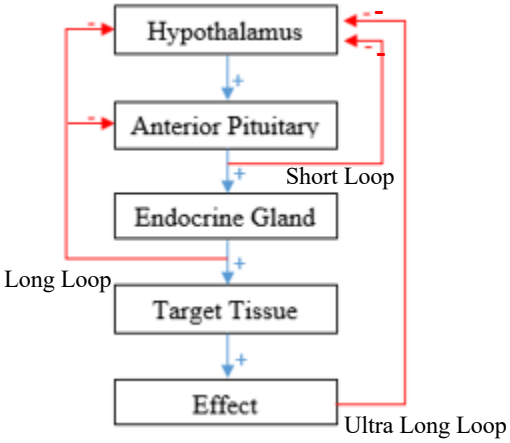
Thyroid Hormones

- **Tetraiodothyronine (T4)** – Thyroxine
  - Contains 4 Iodides
- **Triiodothyronine (T3)**
  - Contains 3 Iodides
- Both require 2 molecules of tyrosine
- Both are hydrophobic and require protein carrier

Thyroid Hormone Secretion

- TSH binds to membrane receptor of thyroid epithelial cells
- Resulting reactions:
  - Taking up iodine
  - Endocytosis of tyrosine-thyroglobulin complex
  - Enzymatic removal of thyroglobulin from T3/T4
  - Secretion of T3/T4
  - Growth of thyroid (hyperplasia)

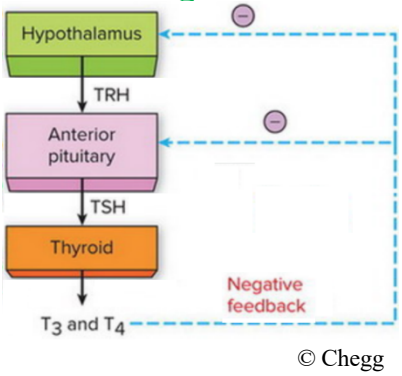
Pituitary Gland Regulation by Negative Feedback



Thyroid Hormone Production

- Epithelial cells take up tyrosine and iodine
- Tyrosine-thyroglobulin complex secreted into colloid
- 1 or 2 iodine molecules (for T3 or T4) added to tyrosine molecules on thyroglobulin
- 2 tyrosine molecules join together

Thyroid Hormone Regulation



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Effects of T3 and T4

- Regulates basal metabolic rate (BMR)
- Increases cardiac output, body temperature, ventilation, food intake, & the breakdown of energy stores
- Needed for fetus nervous system development

Hyperthyroidism
- Excess thyroid hormone
- High basal metabolic rate
- Rapid heart rate, sensitive to heat, weight loss, hyperactive/"nervous" activity

Goiter
- Enlargement of thyroid gland
- Caused by insufficient iodine or too much TRH/TSH
- Hypothalamic tumour → excess TRH/TSH secretion
- Without iodine, T3/T4 not produced. No negative feedback loop so TRH/TSH increases
- Excess TSH causes thyroid growth

Calcitonin
- A protein hormone
- Secreted by parafollicular cells in thyroid
- Decreases blood calcium levels
  - decrease # of osteoclasts
  - stimulates secretion of calcium in urine

Adrenal Gland
- Adrenal glands sit on top of each kidney
- Sympathetic nervous system controls inner medulla
- Pituitary hormones control outer cortex
- Cortex secretes 3 types of steroid hormones
- Zona glomerulosa secretes aldosterone (mineralocorticoid)
- Zona fasciculata secretes cortisol (glucocorticoid)
- Zona reticularis produces androgens (sex steroids)
- Medulla secretes epinephrine (also called adrenaline)

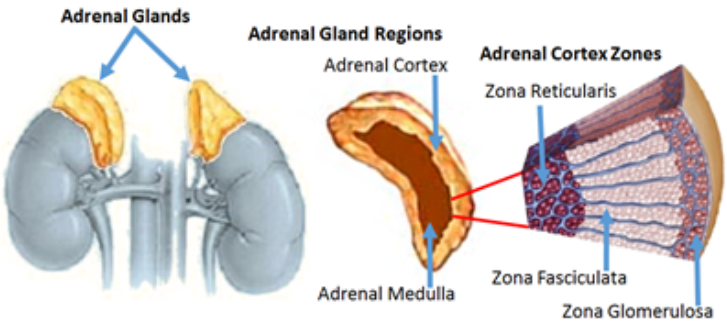
Cortisol
- ACTH stimulates adrenal glands to produce cortisol
- Cortisol levels peak in morning
- Cortisol is a glucocorticoid – helps with glucose metabolism
  - Secreted under stress to increase blood glucose levels
- Catabolic – involved in breakdown of larger macromolecules
- Acts on immune system – immune suppression

The Pancreas
- Contains endocrine and exocrine tissue
- Endocrine tissue has 1-2 million Islets of Langerhans
- <25% alpha cells, 60% beta cells, 10% alpha cells
- Beta cells secrete insulin → causes cells to uptake glucose
- Alpha cells secrete glucagon → stimulates cells to produce glucose through glycogenolysis or gluconeogenesis
  - also releases fatty acids for energy use during exercise
- Delta cells release somatostatin when blood glucose, amino acids or fats increase
  - reduces secretion of insulin and glucagon

Hypothyroidism
- Insufficient amount of thyroid hormone
- Low basal metabolic rate
- Sensitive to cold, weight gain, low blood pressure, slow reflexes, lethargy, fatigue, depression

Cretinism
- A type of hypothyroidism
- Occurs before/after birth or during childhood
- Results in dwarfism & mental retardation

Parathyroid Glands
- Secrete parathyroid hormone (PTH) when blood calcium levels are low
- PTH raises blood calcium levels
  - increase # of osteoclasts
  - decreases excretion of Ca^{2+} in urine



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Cushing's Syndrome
- Excess secretion of cortisol
- Symptoms:
  - wasting of muscles (weakness), thin skin, poor wound healing, fat deposits in cheeks/abdomen, depression

Diabetes Mellitus
- Inability of cells to uptake & utilize glucose
- Results in high blood glucose levels
- **Type 1** Diabetes (juvenile):
  - Damage to insulin-producing beta cells → less insulin
  - increased dehydration, damage to blood vessels, metabolic acidosis, depletion of protein stores
- **Type II** Diabetes (adult onset):
  - Cells become resistant to insulin
  - Eventually leads to decreased insulin release

Review Questions

1. Which of the following is NOT a function of hormones released by the pituitary gland?
   a. Regulate testes growth
   b. Regulate water absorption in the kidney
   c. Controls milk release
   d. Regulates basal metabolic rate

2. A person with an under-functioning pituitary gland will experience functional decline of many systems. All of the following are likely to occur EXCEPT:
   a. Underdeveloped growth
   b. Impaired testosterone secretion in a male
   c. Deficiency of aldosterone
   d. Cessation of menstrual cycles in a female

3. The hypothalamus integrates neural, hormonal and metabolic information and initiates an appropriate response. What is the response to an increase in plasma osmolarity (or 'dehydration')?
   a. Activation of the renin-angiotensin system to decrease aldosterone secretion
   b. There will be increased secretion of releasing factors into the hypophyseal portal system
   c. Vasopressin (AVP, ADH) will be released directly into the bloodstream from the axon termini of bi-polar neurons in the anterior pituitary
   d. The release vasopressin (AVP,ADH) would be suppressed from entering into the bloodstream from the dendrites in the anterior pituitary
   e. None of the above are correct

4. An individual has a damaged thyroid gland and is unable to produce thyroid hormones? Which of the following would you expect to see in this individual?
   a. An increase in the circulating levels of T3 in the blood
   b. An increase in the circulating of levels thyroid stimulating hormone (TSH)
   c. A decrease in the circulating levels of thyrotropin releasing hormone (TRH)
   d. An increase in the circulating levels of T4 in the blood

5. Which of the following statements regarding cortisol is false?
   a. Insufficient secretion of cortisol leads Cushing's syndrome
   b. Cortisol is released from the zona fasciculata in the adrenal glands
   c. An increase in adrenocorticotropic hormone (ACTH) secretion will cause an rise in cortisol levels
   d. Cortisol works generally to breakdown larger macromolecules

6. If a patient is experiencing sensitivity to cold temperatures, weight gain, low blood pressure, and fatigued, what underlying conditions may they have?
   a. Hyperthyroidism
   b. Low levels of iodine
   c. Cushing's syndrome
   d. Type I diabetes

7. If a patient has high levels of calcium in their blood, which of the following is mostly likely to occur?
   a. Parathyroid hormone will be secreted to increase excretion of calcium in urine
   b. Cortisol will be secreted to increase the number of osteoclasts
   c. Hormones from the zona reticularis will be secreted to decrease excretion of calcium in urine
   d. Calcitonin will be secreted to decrease the number and activity of osteoclasts

Answer Key:
1. D 2. C 3. E 4. B 5. A 6. B 7. D

Fill in the following table with the appropriate hormone or target tissue.

Hormone Secreted by Hypothalamus	Anterior Pituitary Hormone	Target Tissues
Gonadotropic Releasing Hormone (GnRH)		
	Thyroid Stimulating Hormone (TSH)	
		Adrenal Glands
Growth Hormone Releasing/Inhibiting Hormone (GHRH/GHIH)		
	Prolactin	

Fill in the blanks.

1. In the pancreas _____ cells produce insulin and _____ produce glucagon. _____ cells release somatostatin.
2. In Type __ Diabetes, there is damage to insulin-producing cells. In Type __ Diabetes, cells becomes resistant to insulin.
3. An excess secretion of _____ is found in patients with Cushing's syndrome.
4. A goiter is an abnormal enlargement of the _____ gland. It can be caused by an insufficient amount of _____.
5. Calcitonin is secreted by _____ cells in the thyroid. It works to decrease blood _____ levels and decrease the number of _____.
6. Parathyroid glands secrete _____ when blood calcium levels are low. It works to increase blood _____ levels and increase the number of _____.
7. In the adrenal gland, the zona glomerulosa secretes _____. The zona fasciculata secretes _____. The zona _____ produces androgens (sex steroids). The medulla secretes _____.
8. Cortisol is secreted under conditions of _____. It helps with _____ metabolism. It is also involved in _____ suppression.

A Western Connection – Insulin

- Sir Frederick Banting received the Nobel Prize in 1932 for the co-discovery of insulin and its therapeutic potential. He conceived his Nobel Prize-worthy idea while teaching at Western.
- He discovered a way to extract insulin from animals (first dogs and then pigs/cows) which could then be used to treat diabetes in humans
- Since the 1980s, commercially available insulin has been produced synthetically

Choose the correct answer.

1. In certain parts of the world, the salt consumed has not been iodized. What could possibly arise from a person's diet lacking iodized salt or any other sufficient iodine source?
   a. Cretinism - Hypothyroidism
   b. Goiter – Hyperthyroidism
   c. Goiter – Hypothyroidism
   d. Cretinism – Hyperthyroidism
2. A daily consistent amount of insulin is most effective in treating which disease?
   a. Type I Diabetes
   b. Type II Diabetes
   c. Cushing's Syndrome
   d. Cretinism

Answers:

Fill in the blanks

5. beta, alpha, delta
6. I, II
7. cortisol
8. thyroid, iodine
9. parafollicular, calcium, osteoclasts
10. parathyroid hormone (PTH), calcium, osteoclasts
11. aldosterone, cortisol, reticularis, epinephrine
12. stress, glucose, immune

Multiple choice

3. B
4. A